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A pluralist approach to argument diagramming

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There is a long history of argument diagramming mechanisms, attesting to the need for, and popularity of visualizations of reasoning patterns in general. Many of these approaches have given rise to software implementations that serve particular audiences with particular needs, leading to a plethora of such tools. Interesting research questions are posed when exploring the ground between these different approaches to diagramming, and these questions become operational challenges in the context of a research programme aimed at developing 'pluralist' argument diagramming software—a single tool that supports multiple different theoretical approaches to the analysis of argument. The *Araucaria* system aims to meet such pluralist goals, by allowing analysis to be conducted in different styles and then providing for translation between them. In this way, a potential is opened up for interchange between different communities.

Keywords: argument diagramming; Beardsley; diagrams; Toulmin; Wigmore.

1. Introduction

There is a long tradition of interaction between evidential reasoning and argument diagramming at all stages of legal processes from investigation through preparation to presentation and summing up. Sometimes, such diagramming is informal and *ad hoc* with participants using rough, hand-drawn analyses as the material is organized and developed. At other times, more formal mechanisms such as Toulmin's (1958) argument schema might be used to organize information. Then again, there are diagramming methods for arranging legal arguments in general and evidential material in particular, with Wigmore's (1913) elaborate charting method the canonical example.

Increasingly, such schemes, techniques and methods are being computerized to provide support for the investigative, preparatory, presentational and summing up and analytical processes. So, e.g. the Argument Visualization for Evidential Reasoning system (van den Braak and Vreeswijk, 2006; Bex *et al.*, this volume) supports crime investigation; many loosely structured systems flexibly support discussion, preparation and presentation with Compendium (Kirschner *et al.*, 2003), one of the most widely known; the main system discussed in this paper, Araucaria, is being used for preparing summing up arguments (see Section 1.1) and also supports Wigmorean analysis of existing cases.

This paper discusses a 'pluralist' approach to such tools that admits multiple theoretical approaches to argument and evidence into a single coherent system—bringing together, e.g. the Toulmin diagramming technique with the Wigmore charting method. Before reviewing the history

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of these techniques and showing in detail how they can be related, we start with a brief description of some applications, both in legal practice and in further afield, that serve to provide motivation for what follows. In order to ground these applications and provide a common thread with the technical material that follows, we focus on the Araucaria system (Reed and Rowe, 2004). Araucaria is a software tool developed in the Argumentation Research Group at the University of Dundee[1]. It is designed to support a wide variety of users in analysing the structure of textual argument.

As freely downloadable software, it is difficult to estimate the size of Araucaria's current user group accurately; web server logs indicate between 1000 and 2000 downloads to unique IP addresses each year since 2001, and a further 1000 or so package CDs have been distributed. The software has wide geographical appeal (with Chinese and Hebrew versions in development) with known users in over 40 countries, but more surprising is the range of domains, including not just the academic and pedagogic domains that might be expected but requests have also been received demonstrating the use of the software by engineers building safety cases, barristers preparing cases, doctors conducting complex diagnoses, statisticians representing test designs and more. Here, we focus on two of the more significant user groups.

1.1 *Applications in legal practice*

In 2004, Araucaria was evaluated by a number of magistrates in the Ontario Court of Justice. The remit of magistrates in Ontario is interesting because it covers a wide range of cases from the mundane to the headline hitting. Specifically, at one end of the scale, magistrates are faced with processing traffic violations, and this represents a huge majority of the caseload, with 60–70 cases requiring attention per day. Each case is small and follows a stereotypical pattern in which the number of alternative arguments and decisions is relatively small. On the other hand, there are much rarer, but much larger environmental law cases involving, from time-to-time, large, multinational corporations. These cases can be protracted, lasting weeks or months, and can involve huge amounts of testimony and argument. Informal trials were set up by the magistrates themselves to explore the potential role of software in the process of preparing summing up arguments. The trials demonstrated that software tools, and Araucaria in particular, were found to be useful in the large complex cases—and that is exactly where a computer scientist's intuition would expect a tool to play a significant role. Much more interesting, therefore, was the feedback that Araucaria was also being used extensively in processing the smaller cases and, specifically, that by setting up a small number of argumentation schemes, magistrates were able to very rapidly go through the associated critical questions as a kind of check list (and a number of minor modifications of the Araucaria interface were tailored to this process to streamline interaction). As a result, a programme of roll-out has been initiated for all new appointments, which will eventually cover the entire magistracy in the province—over 400 individuals. Larger scale trials and feedback mechanisms are planned.

1.2 *Applications in education*

The majority of Araucaria's users are probably instructors and their students. The development team has had close contact with three undergraduate courses, one in philosophy at Winnipeg, one in legal theory at Groningen and one in argument and computation at Dundee. Student users—particularly those outside the computational sciences—make for demanding requirements on software, and it is

[1] See http://arg.computing.dundee.ac.uk.

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through many hundreds of students' feedback that the software has been updated on a rolling basis. The ability to do simple graph matching automatically has been a great boon for instructors with large class sizes (which are characteristic of North American critical thinking courses in particular). For although complex arguments have too many potentially 'right' analyses for completely automated marking to be feasible, smaller exercises with less variability and interpretability are well within the scope of Araucaria's automatic marking, and provide instructors with much more flexibility than is afforded by traditional multiple-choice alternatives. Full classroom evaluations of critical thinking software is fraught with difficulties, but following the trailblazing of Reason!Able's assessments (Twardy, 2004) and the requirements for the process laid out in van den Braak *et al.* (2006), Araucaria will be undergoing controlled assessment as part of its longer term development.

The use of argument diagramming in both educational and legal contexts is founded upon a long tradition that has seen various schools and approaches emerge, each of which now have their adherents and advocates. In education, e.g. Toulmin's (1958) model is often very popular. Some legal analysts make heavy use of Wigmore's (1913) approach. Section 2 reviews the tradition as a whole showing how the different schools are interrelated.

2. History of argument diagramming

The diagrammatic analysis of reasoning is a common feature of both pedagogy and practice in many fields where sophisticated reasoning is required. Many of these fields have developed their own traditions of assumptions, structures and approaches to such diagramming. With computer support for analysis becoming increasingly available, the relationships between these different styles of argument diagramming have started to be explored in some detail.

Reed *et al.* (2007) have carried out an extensive review of argument diagramming techniques in the 19th and 20th centuries with an emphasis on legal and philosophical domains. Here, our aim is to sketch the main traditions and how those traditions structure recent work in the area in philosophy, law and computer science.

Figure 1 summarizes the genealogy of approaches to argument diagramming. Most modern approaches are more or less rooted in Whately's style of graphing the links between premise and

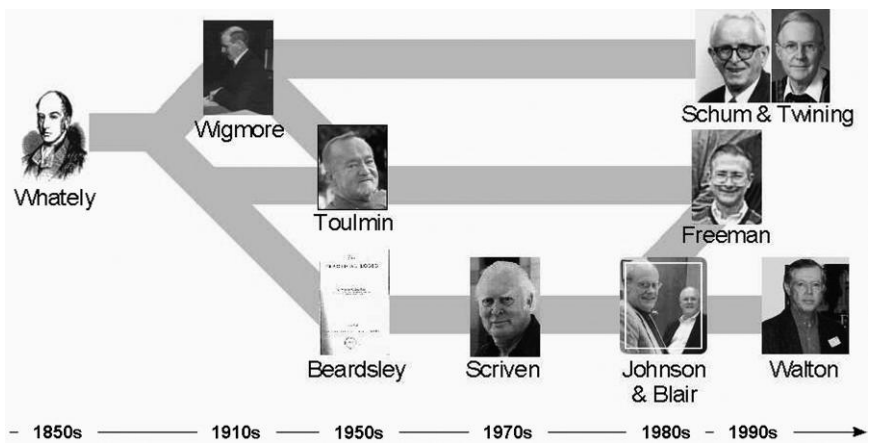

FIG. 1. A genealogy of argument diagramming techniques.

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conclusion identifiers (Whately, 1850). The early 20th century saw the development of Wigmore's elaborate mechanisms for detailing the structure of legal cases, including explicit marking of prosecution and defence, categorization of evidential types and an indication of probative strength (Wigmore, 1913). Forty years later, two further approaches cemented the foundation for almost all the work that followed. First, Toulmin (1958), in an attack on the formal logic approach to understanding reasoning, developed a six-part structure for understanding field-dependent reasoning with a jurisprudential focus; associated with that structure was a simple diagram layout, which has since become very popular in teaching critical thinking. Second, Beardsley (1950) (better known for his philosophy of aesthetics) provided the first explicit account of basic types of argument structures and how they can be composed, giving a diagrammatic summary that has influenced most critical thinking texts from that point on.

These three traditions, the Wigmorean, the Toulminian and the Beardsleyan, have each enjoyed further developments, refinements and extensions. The Wigmore approach suffered in its original form from a surfeit of evidential and inferential types which practitioners can find hard to use correctly, particularly as many of them are rarely if ever exemplified in Wigmore's writings. Anderson *et al.* (2006) have consolidated, simplified and updated Wigmore's original into a diagramming method that is well structured, well organized and that has value for both the classroom and the practitioner. Beardsley's approach was extended for pedagogical purposes by Scriven (1976), and this work initiated the growth of what, after the landmark book of Johnson and Blair (1977), became known as *informal logic*. One of the most prolific contributors to this field and certainly one of its foremost ambassadors across interdisciplinary borders is Walton, who has worked at extending the informal logic account of reasoning to deal with phenomena such as fallacies (Walton, 1995) and stereotypical patterns of reasoning (which bear resemblance to Toulmin's field-dependent warrants) known as argumentation schemes (Walton, 1996). It is also under the auspices of informal logic that Freeman has developed the original Toulmin model to rectify some of its shortcomings and provide a more general account of features such as modality Freeman (1991).

The purpose of this very brief and simplified account of the history of the area is to identify these three branches in the genealogical tree, because each of them has been a source of new developments in computer support for argument.

3. Software for argument diagramming

A complete review of argument diagramming software is not just beyond the scope of this paper but increasingly a Herculean task, particularly if the scope is taken to include the more generic systems that support exploration of ideas and 'mind mapping'. We restrict ourselves here to a small selection of indicative systems and some pointers to other, more thorough review works.

- **ArguMed** and its predecessor **Argue!** are targeted at users and creators of legal arguments. Its visual language is structured around an idiosyncratic style resulting from the underlying logic, but that is most similar to the Toulmin approach (Verheij, 2005).
- **Athena** was one of the earliest Beardsley-style mapping tools used primarily in educational settings (Rolf and Magnusson, 2002).
- **Belvedere** also uses interactive Beardsley-style diagrams, though with a specific focus on scientific reasoning based on evidence and hypotheses. It has been extensively tested in classroom use (Suthers *et al.*, 1995).

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- **ConvinceMe**, like Belvedere, is focussed on a scientific style of reasoning, combined with a probabilistic component. It too uses a variation of Beardsley diagrams (Adams, 2003).
- **iLogos**[2] is based on Toulmin diagrams, extended to focus on causal arguments and integrate media resources.
- **Rationale** and its predecessor **Reason!Able** are commercial software products that use a style of diagrammatic presentation that is very close to Beardsley's notation, with only a small number of additional conventions (van Gelder, 2001).
- **Room5** is an early system for analysing legal cases. Though not strictly diagrammatic, it makes heavy use of tabular layout in its web presentation in order to describe argumentative structure. The underlying relationships are based on the Toulmin account (Loui *et al.*, 1997).
- **SEAS**, the Structured Evidential Argumentation System, provides a rich set of visual interfaces for constructing and assessing arguments concerning military intelligence. Those that focus on argument structure are adapted from the Beardsley approach (Lowrance, this volume).
- **Truthmapping**[3] provides an online web interface for constructing arguments collaboratively. It displays a simplified Beardsley-style diagram as the argument is developed.

Kirschner *et al.* (2003) provide a collection of papers discussing a range of different argument mapping techniques with a focus on collaborative argumentation (such as that found at planning meetings). Harrell (2005) reviews almost a dozen argument mapping systems with a view to selecting tools for classroom use in support of teaching critical thinking. The history of argument diagramming techniques and some of their recent implementations in software is reviewed in Reed *et al.* (2007). Finally, there are many online resources that collect together systems for argumentation. One of the most complete is provided on the iLogos web page.

What all these software systems have in common is the assumption that there is a single-most appropriate technique for diagramming arguments for their target audiences and users—though the techniques obviously differ significantly between these systems. The continuing research on the Araucaria system at Dundee (Reed and Rowe, 2004) has instead adopted a 'pluralist' approach to software support for argument diagramming. For Araucaria, the rich variety of techniques for diagramming is seen as an inevitable feature of a widely cross-disciplinary skill such as critical thinking and one that demands explicit handling and support. The fact that diagramming legal evidence demands distinction between prosecution and defence, e.g. is an intrinsic feature of arguments in the legal domain—and not one that should clutter up the analysis of, e.g. arguments found in letters to the editor of a daily newspaper.

4. Pluralism and the challenges of pluralism

As the simplified genealogy in Fig. 1 suggests, there are numerous different approaches to diagramming argument and there are then any number of variations, specializations and enhancements of each. No two tools listed in Section 3, e.g. implement exactly the same schema for diagramming.

In some cases, divergence in approach arises from the whim or focus of the authors of the work, and what might be decided on a whim by one author may be of vital importance to another: a mechanism for diagramming the inference in an argument may be inconsequential to the classical

[2] See http://www.phil.cmu.edu/projects/argument_mapping/.
[3] See http://www.truthmapping.com.

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logician, for whom there is only a single type of such inference (i.e. the deductive); whereas for a rhetorician diagramming, the distinction between tens or even hundreds of rhetorical figures may be a central concern.

In other cases, divergence may be superficially minor, but may represent deep philosophical or methodological differences. So, e.g. Wigmore's arrangement of evidence below, left and right of claims is a little different from the Beardsley-style approach of arranging all evidence beneath. But for Wigmore, there are deep and important distinctions between testimonial, circumstantial and corroborative evidence (so deep, in fact, that they take priority over any other stage of the analysis), whereas that cladistic simply does not occur in any other theory.

The job for a pluralist approach is to support a multitude of different theoretical approaches simultaneously, provide a mechanism for altering theoretical viewpoint and construct an environment—or in our case, a software tool—that is of significant utility not only to those who are interested in comparative or cross-theoretical research but also to those who work within a single theoretical domain. By doing this, we create an opportunity for dialogue and exchange between these communities that has direct, tangible benefits in the sharing of resources and results and also more intangible benefits in increasing the accessibility of research between the different areas.

The challenge for pluralism is to support such multiplicity not just among differences that are the result of whim and focus but also among differences that result from the deep theoretical disagreements.

In the remainder of this section, we describe three theories that have both surface and deep differences in their approach, and then in Section 5, go on to show how a pluralist approach can bridge the gaps between them.

4.1 *Diagramming the standard account*

The most common diagramming technique does not have an official name, so we will refer to it simply as a *standard* diagram. It corresponds to the 'Beardsely' thread in the genealogy of Fig. 1. A standard diagram is a tree with the conclusion of the argument as the root node. Some authors draw the root node at the top of the tree, while others invert the tree so that the root node is at the bottom of the diagram. We will use the former convention although Araucaria allows either type of diagram.

Each node in the diagram can be supported by one or more additional nodes, each of which represents a premise in the argument. Premises can be of two main types: *convergent* or *linked*. A convergent premise stands on its own as support for another node, while a linked premise must link with one or more other premises to form support. As an example, the argument 'Pelser was under a bench when the shooting started because Constantino so testified and Pelser himself admitted as much under cross examination' consists of a conclusion ('Pelser was under a bench. . . ') supported by two convergent premises ('Constantino testified that Pelser was under a bench' and 'Pelser admitted under cross examination that he was under a bench').[4] Either premise provides support for the conclusion without the other although the two together form a stronger argument than either on its own. A convergent premise is drawn as a node with a single arrow leading to the conclusion it supports, as shown in Fig. 2.

[4] This example and a number that follow are drawn from the case of Sacco and Vanzetti analysed by Kadane and Schum (1996).

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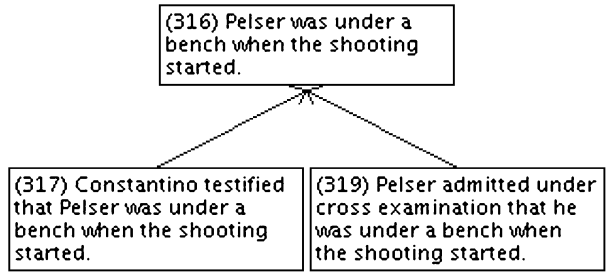
(316) Pelser was under a bench when the shooting started.
(317) Constantino testified that Pelser was under a bench when the shooting started.
(319) Pelser admitted under cross examination that he was under a bench when the shooting started.

FIG. 2. A simple convergent argument in Araucaria.

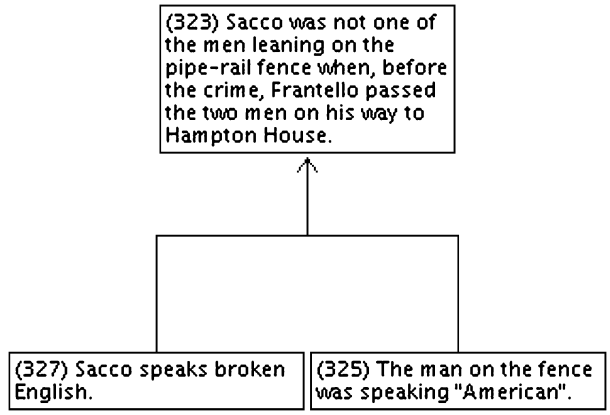
(323) Sacco was not one of the men leaning on the pipe-rail fence when, before the crime, Frantello passed the two men on his way to Hampton House.
(327) Sacco speaks broken English.
(325) The man on the fence was speaking "American".

FIG. 3. A simple linked argument in Araucaria.

Figure 3 gives an example of a linked argument, in which the text runs, ‘Sacco was not one of the men leaning on the fence since Sacco speaks broken English and the man on the fence was speaking “American”.’ Here, the conclusion is that ‘Sacco was not one of the men leaning on the fence’ and this is supported by the premises ‘Sacco speaks broken English’ and ‘the man on the fence was speaking “American”.’ These two premises are linked because neither on its own is a sufficient evidence from which to draw the conclusion that Sacco was not leaning on the fence. Linked premises are shown as connected by a horizontal line which in turn gives rise to a single arrow connecting all linked premises in that group to the conclusion they support.

Standard diagrams support the notion of a *refutation*, which is an argument that refutes or argues against another node in the diagram. In propositional logic, the notion of refutation is that for a given statement P, there is a statement not P which is the logical opposite of P. Since each statement can have only one logical opposite, the standard diagram allows only a single refutation for any given node. Of course, in a ‘real’ argument, there could be a number of arguments against a given proposition. In the standard diagram, such a situation is represented by creating the single refutation node for the proposition which is to be refuted, and then to draw in the various arguments against the proposition as supports for the refutation. To continue the example above, the refutation to the conclusion ‘Sacco was at the scene of the robbery and shootings when they occurred’ is ‘Sacco was

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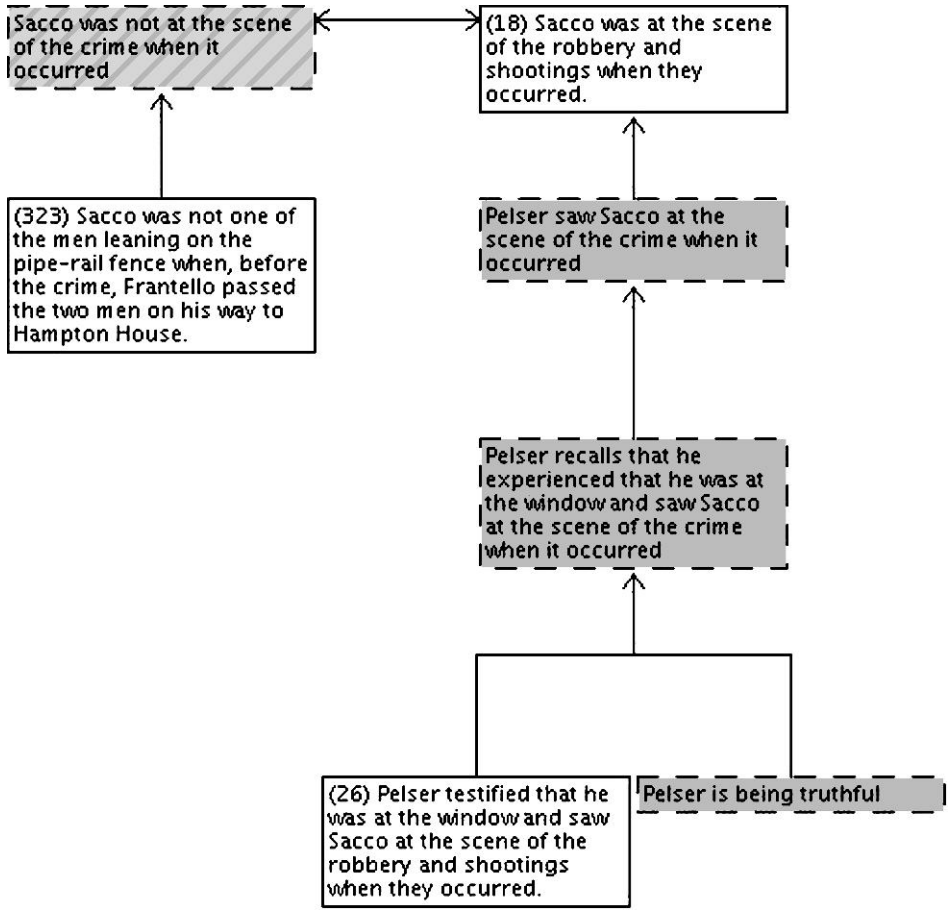
Sacco was not at the scene of the crime when it occurred
(18) Sacco was at the scene of the robbery and shootings when they occurred.
(323) Sacco was not one of the men leaning on the pipe-rail fence when, before the crime, Frantello passed the two men on his way to Hampton House.
Pelser saw Sacco at the scene of the crime when it occurred
Pelser recalls that he experienced that he was at the window and saw Sacco at the scene of the crime when it occurred
(26) Pelser testified that he was at the window and saw Sacco at the scene of the robbery and shootings when they occurred.
Pelser is being truthful

FIG. 4. An argument with a refutation.

not at the scene of the crime when it occurred'. This refutation could be supported by the proposition 'Sacco was not one of the men leaning on the fence…' as shown in Fig. 4.

In Araucaria, a refutation is drawn as a node to the left of the proposition it is refuting and connected to the proposition by line with arrows on both ends.

In addition to the basic structure of the tree in a standard diagram, Araucaria supports several other features. An argumentation scheme (Walton, 1996) can be drawn by selecting several supports or nodes and then selecting the scheme to which they belong. This is shown in the diagram by a coloured outline of the selected supports and nodes. Full information on the particular scheme can be obtained by bringing up a dialog box which displays the role of each premise in the scheme and which critical questions have been answered. In addition, Araucaria allows the editing and creation of sets of schemes, so the user can customize existing scheme sets or create new ones (the software currently supports approaches to schemes advocated by Walton (1996), Grennan (1997), Perelman and Olbrechts-Tyteca (1969), Katzav and Reed (2004) and Pollock (1995)).

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In the example above, the claim that 'Sacco was at the scene of the crime…' is supported by a chain of argumentation that is a stereotypical pattern of reconstruction using the argumentation schemes provided by Pollock (1995) as extended by Bex *et al.* (2003). According to this account, a witness's testimony lends credence to the witness's statement that they do, in fact, recall the event at hand (i.e. that they are honest) by the presumptive argumentation scheme of Witness Testimony. That recollection in turn gives credence to the fact that the witness did, in fact, perceive the event (i.e. that they remember) by the presumptive argumentation scheme of Memory. Finally, that experience of perception supports the claim that the event did in fact take place by the presumptive scheme Perception. Each of these schemes has built in to it a set of presumptions and (thereby) a set of ways in which it can be challenged. Figure 5 shows the schemes added to the diagram shown in Fig. 4. (See Walton (1996) for a more detailed investigation of how argumentation schemes function.)

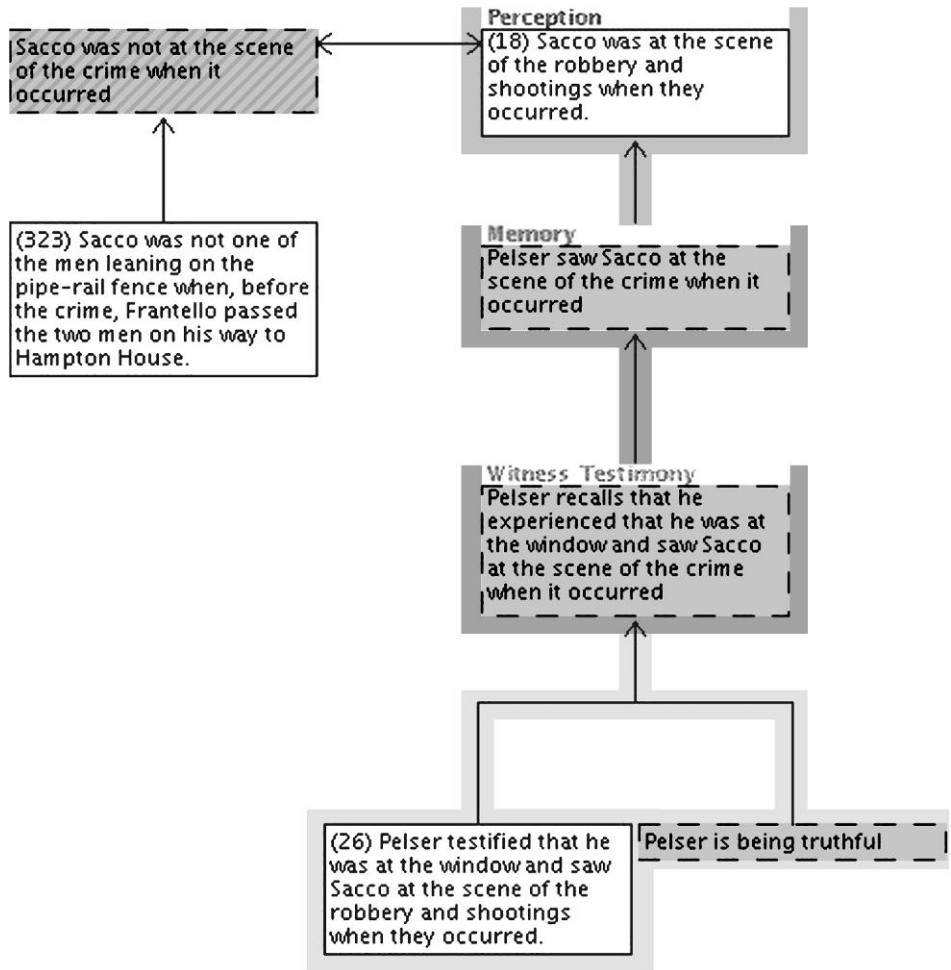
Sacco was not at the scene of the crime when it occurred
Perception
(18) Sacco was at the scene of the robbery and shootings when they occurred.
(323) Sacco was not one of the men leaning on the pipe-rail fence when, before the crime, Frantello passed the two men on his way to Hampton House.
Memory
Pelser saw Sacco at the scene of the crime when it occurred
Witness Testimony
Pelser recalls that he experienced that he was at the window and saw Sacco at the scene of the crime when it occurred
(26) Pelser testified that he was at the window and saw Sacco at the scene of the robbery and shootings when they occurred.
Pelser is being truthful

FIG. 5. The refutation and scheme usage.

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When analysing text, different propositions can be derived from different sources. For example, prosecution might decide to present defence's argument either to refute it, to show its weaknesses or to adapt it to serve their own claims—but in analysing such a text, we would want to mark that its different parts have different *owners*. In Araucaria, each proposition can be marked to identify that it was originated by (or is, in the analyst's opinion, the responsibility of) one or more owners, which can be defined as text strings.

In a natural argument, some propositions will have greater strength or force than others. This is particularly important in an evidential context, where weighing up the contribution made by a particular item of evidence is key. In a standard diagram, a force can be represented as an *evaluation* of the support line connecting two propositions or a proposition itself. Typically, an evaluation is a modality such as 'possibly' or in some cases, a number such as a percentage value which indicates how strong the inference is between the two nodes. Numerical relationships of this sort bring to mind probabilistic reasoning and Bayes nets in particular. There are strong resonances with tools for visualizing Bayes networks such as VisNet (Zapata-Rivera *et al.*, 1999), but it is important to note that Bayesian reasoning is both more powerful (in terms of the processing that can be automated) and more limited (in terms of the flexibility of representation and network topology) than argument structures of the sort handled by Araucaria.

4.2 *Diagramming the Toulmin account*

The Toulmin (1958) diagram in its original form is based on the datum–warrant–claim (DWC) complex. The claim is the conclusion of the argument which is supported by the datum. The warrant provides justification for the statement that the datum supports the claim. Thus, the DWC seems closest to the notion of a linked argument in a standard diagram. We might say that Pelser's testimony (the datum) gives us reason to think that he really does think that he saw what he says he saw (the claim). The reason—or *warrant*—that licenses this inference says, roughly, that witnesses are usually honest. In Araucaria, a warrant is drawn as a green node with a link into the line connecting the datum and the claim, and is explicitly labelled 'warrant'.

A simple Toulmin diagram containing only a single DWC complex is drawn as in Fig. 6. The datum is on the left and connects to the claim on the right by a horizontal line. The warrant links into the line from below as shown. The diagram thus illustrates the idea that the warrant supports the inference from datum to claim, rather than the claim directly. This diagram is produced by Araucaria as a direct translation of a standard diagram in which Pelser's testimony and his honesty are linked premises for the claim. See below for a discussion of the translation of diagrams.

A Toulmin diagram provides the *rebuttal* as the mechanism for rebutting an argument. A rebuttal appears as another node that links into the DWC by a vertical line from below. The fact that the

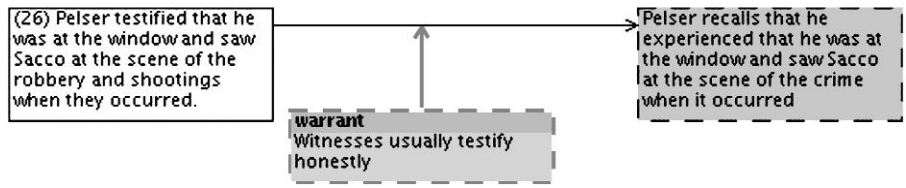
(26) Pelser testified that he was at the window and saw Sacco at the scene of the robbery and shootings when they occurred.
Pelser recalls that he experienced that he was at the window and saw Sacco at the scene of the crime when it occurred
warrant
Witnesses usually testify honestly

FIG. 6. A Toulmin diagram showing the basic DWC complex.

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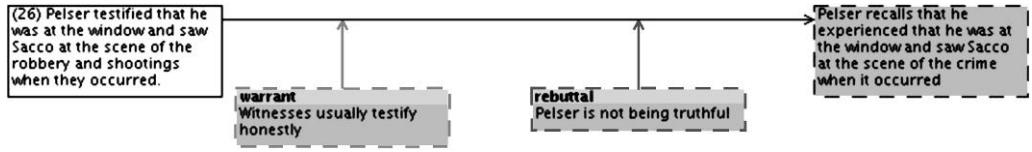
(26) Pelser testified that he was at the window and saw Sacco at the scene of the robbery and shootings when they occurred.
warrant
Witnesses usually testify honestly
rebuttal
Pelser is not being truthful
Pelser recalls that he experienced that he was at the window and saw Sacco at the scene of the crime when it occurred

FIG. 7. A Toulmin diagram with a rebuttal.

rebuttal also impacts on the link between datum and claim shows that it attacks the inference from datum to claim, rather than being a strict negation of the claim as is the case with the refutation node in the standard model. In the example above, we might add a rebuttal to the argument by saying that 'Pelser is not being truthful' which would cause the argument to default. (Of course, we might demand some support for the claim of Pelser's dishonesty, as was provided in the case from which these examples have been drawn.) The correspondence between the Toulmin rebuttal and the standard refutation is discussed in more detail below in the section on translating Toulmin diagrams. In Araucaria, the Toulmin rebuttal is drawn as a red node connecting to the datum–claim link, as shown in Fig. 7.

The final feature in a Toulmin diagram is the *qualifier*. A qualifier plays roughly the same role as an evaluation in standard: it provides a measure of the confidence in the DWC complex. Qualifiers are also attached to the link between datum and claim, and are indicated in Araucaria as yellow triangular nodes.

4.3 *Diagramming the Wigmore account*

A diagramming model was produced by Wigmore in the early 20th century to allow diagrams of evidential arguments in legal settings. The structure is superficially similar to the standard diagram in that the argument is drawn as a tree with the root node at the top, but there are some important differences. Usually, there are two main trees for a single court case: one for the argument from the prosecution and the other for the defence. Within each tree, the top-level node is typically the central charge in the case which is to be either proved, in the case of the prosecution, or refuted, in the case of the defence. We will consider the prosecution's argument in what follows.

The root node can have three groups of nodes connected to it (see Fig. 8). The main evidence supporting the central charge is presented as a block of testimonial or circumstantial nodes. Testimonial evidence is evidence introduced as testimony by witnesses, so could consist of accounts of what the witnesses saw, or other evidence supposedly known as facts by the witnesses. Circumstantial evidence is evidence that is inferred from other facts, such as 'the defendant was seen in the house at the time of the murder and his fingerprints were on the gun, so it can be inferred that he shot the deceased'. This group of nodes thus corresponds to the basic facts (or statements that can be presumed to be facts since they were given under oath) pertaining to the charge. Nodes 2 and 3 in Fig. 8 represent these arguments (we will consider node 7 below).

The second group of nodes contains corroborative evidence. This is evidence introduced to support the central charge or evidence that is testimonial or circumstantial. Thus, corroborative evidence is introduced on the side of the party attempting to establish the claim in the root node and would be seen as supportive evidence in the context of the argument. In the argument above, the claim that 'the defendant was known to dislike the deceased' could be introduced as corroborative evidence since

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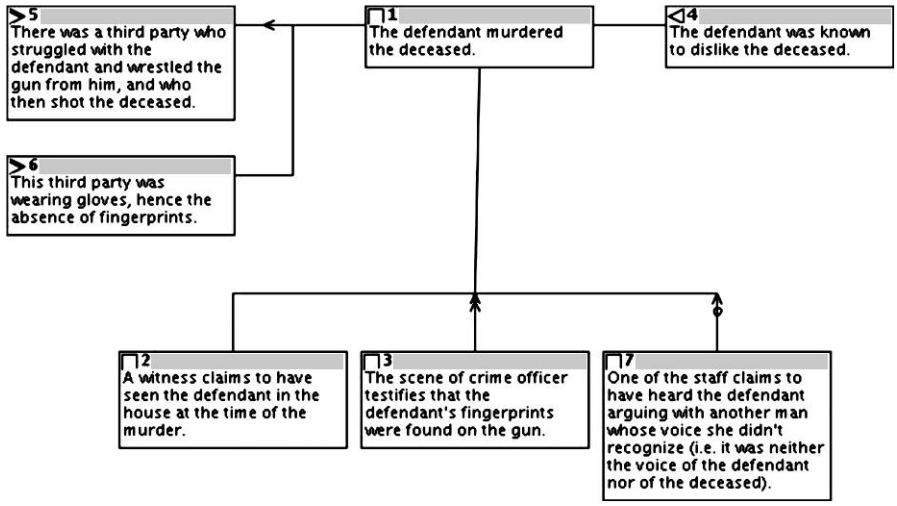
5
There was a third party who struggled with the defendant and wrestled the gun from him, and who then shot the deceased.
1
The defendant murdered the deceased.
4
The defendant was known to dislike the deceased.
6
This third party was wearing gloves, hence the absence of fingerprints.
2
A witness claims to have seen the defendant in the house at the time of the murder.
3
The scene of crime officer testifies that the defendant's fingerprints were found on the gun.
7
One of the staff claims to have heard the defendant arguing with another man whose voice she didn't recognize (i.e. it was neither the voice of the defendant nor of the deceased).

FIG. 8. A Wigmore diagram.

it establishes motive. The distinction between corroborative and testimonial evidence is not precise and is in many cases subjective. Node 4 in Fig. 8 shows the corroborative argument.

The third group of nodes contains explanatory evidence. This is evidence introduced by the opposite side in the case, and it attempts to lessen the credibility or deny outright the claim being made. In the above example, the defence may introduce the explanatory evidence that 'there was a third party present who struggled with the defendant and wrestled the gun from him, and who then shot the deceased. This third party was wearing gloves, hence the absence of his fingerprints'. Nodes 5 and 6 in Fig. 8 show the above evidence as two explanatory arguments.

In summary, Wigmore distinguishes four types of evidence: testimonial (covering human assertion), circumstantial (covering other factual evidence), explanatory (covering 'explaining away' circumstantial evidence and 'discrediting' testimonial evidence) and corroborative (covering the 'strengthening of inference' of circumstantial evidence and 'closing up possibilities of ... error'[5] in testimonial evidence). Determining what, in practice, constitutes an element of a given sort is described briefly by Wigmore, with the implication that it is an easy process to the point of being selfevident. His examples (Wigmore, 1913, p. 754, and elsewhere) belie such simplicity, however, demonstrating the ambiguity and challenge of analysis. In what follows, we follow in the spirit of Wigmore's approach, grouping together the 'primary' evidential types of testimonial and circumstantial evidence and the 'secondary' evidential types of corroborative and explanatory where it is convenient to do so.

In a Wigmore diagram, these three sets of nodes are placed in specific locations relative to the node they support (or deny, in the case of explanatory evidence). The testimonial/circumstantial nodes are placed below the central node, the explanatory nodes are on the left and the corroborative nodes are on the right. All nodes within each group are drawn as linked into a single support arrow, which in turn impinges on the central node.

[5] All quoted terminology is from Wigmore (1913, p. 751).

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The nodes and edges in a Wigmore diagram have a variety of symbols that are used to adorn them. We will not give a complete catalogue here, but an outline of the main categories of these symbols will be useful.

Each node itself can be an evidence introduced by either the prosecution or the defence, thus the symbols for the various nodes occur in pairs. The main symbol for each type of node is defined for the prosecution, and the corresponding symbol for the defence adds an extra horizontal bar within the symbol. Thus, the symbol for testimonial evidence introduced by the prosecution is a square, and for similar evidence introduced by the defence, it is a square with a horizontal line drawn inside it. In Fig. 8, the symbols are shown to the left of the identifying number in the top line of each text box. The original Wigmore diagram showed only the symbol and associated number, and the analyst had to make reference to a separate text to provide the link between the diagram and the case notes. Araucaria allows both the full-text version of the Wigmore diagram (shown in Fig. 8) and the traditional version to be drawn.

The connections between nodes can have a variety of symbols added to them. An unadorned line indicates some 'average' degree of support. Extra force in the support is indicated by adding various arrowhead or cross symbols (depending on the particular link), while a lessening of support, as might occur in with an explanatory node which argues against the claim, is indicated by a backwards-pointing arrowhead. In Fig. 8, e.g. the double arrowhead leading from node 3 indicates strong support for the conclusion. The backwards arrow on the link from node 5 indicates that node 5 detracts from the conclusion. The X on the line from node 4 indicates that corroborative node 4 reinforces the conclusion. There are a number of other symbols that can be used to indicate varying degrees of support between nodes.

Wigmore distinguishes between the support provided by individual nodes and the aggregate support provided by all the nodes in a particular group. For example, in the set of testimonial nodes, each node in the set can have its own influence on the claim by being assigned its own degree of force. Some nodes may have average force, some strong and others very strong force. Taken together, the net effect of all the nodes in the group may be judged by the analyst to have 'strong' (as opposed to 'average' or 'very strong') force, so the single link leading from the line that groups all the nodes together can be assigned a symbol indicating what Wigmore calls the 'net probative force' of all the testimonial nodes taken together. The line joining the set of nodes 2, 3 and 7 to the main conclusion is shown with a single arrow on it, which indicates that the net probative force of these three nodes is 'provisional'.

We have seen that the explanatory nodes provide a type of refutation or rebuttal mechanism in that they represent evidence provided by the opponent of the main claim. However, individual or aggregate links in a Wigmore diagram can be labelled as *negatory* nodes by placing a small circle on the line in the diagram. Wigmore is not entirely clear what this negatory symbol means, but it seems from the few examples he provides that it is intended to indicate that the evidence does not support the claim. Thus, a testimonial node in the example given above might state 'I heard the defendant arguing with another man whose voice I didn't recognize (i.e. it was neither the voice of the defendant or the deceased)'. If this evidence was given by a prosecution witness, it would be included in the diagram as a testimonial node but given negatory force since it does not support the prosecution's claim that the defendant and deceased were alone in the room at the time of the shooting. This node is shown as node 7 in Fig. 8.

A hallmark of Wigmore diagrams is that many of the assignments of force or even the group into which a given bit of evidence is inserted can be quite subjective. The degree of force assigned

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to a particular node or whether a node is testimonial or corroborative could vary from one analyst to another. The Araucaria representation of Wigmore diagrams is flexible enough to allow editing of the diagram to suit any taste.

5. Translation

5.1 *Motivation and desiderata*

Argumentation theory enjoys a rich scholarly debate about how best to conceive of and, then, analyse real argumentation. There is no general consensus because different authors tend to focus on different aspects. The approach taken by the Araucaria project has been to try to support this diversity while maintaining a core coherence and to do so by engineering pragmatic solutions for translating between the different styles of theoretical and practical analysis.

Our experience working with these multiple theoretical approaches to argument analysis has yielded *desiderata* for the process:

(i) Translation should be deterministic, always providing the same output for any given input.
(ii) Translation should be 'symmetrical', i.e. translation from A to B should be 1:1 and onto, as should back-translation from B to A so that back-translation from translation is always equivalent to identity.
(iii) Translation should make maximal use of a common interlingua where possible.
(iv) Where (iii) cannot be met, theory-specific analysands should be included by extending the interlingua.

In the implementation of Araucaria, the role of the interlingua is played by the argument markup language (AML), a standard XML-based language which may be used to represent arguments, though in principle a more flexible system such as the argument interchange format (AIF) (Chesñevar *et al.*, 2006) could be used. Here, we explore the translation of Toulmin and Wigmore diagram types into standard notation and back again.

5.2 *Translating Toulmin analyses*

In translating from a Toulmin diagram to a standard diagram, we need to consider the various components of a Toulmin diagram and how they correspond to features in a standard diagram. The elements of a Toulmin diagram we will consider are atoms, warrants, backings, qualifiers and rebuttals.

5.2.1 *Atoms.* Although the notion of what constitutes an argument or an atomic component of an argument (Katzav and Reed, 2004; Parsons, 1996; Wreen, 1998) is highly contentious, we will adopt the view that there is little difference between atomic statements in any of the models of argument. A standard premise can serve as a Toulmin datum or warrant, e.g.

5.2.2 *Warrants.* The simplest construct in a Toulmin diagram is the DWC complex. The warrant can be interpreted (Freeman, 1991) as a reason for the datum being relevant to the claim. As such, it is reasonable to interpret the datum and warrant in a DWC as a pair of linked premises in the standard model. Figure 9[6] shows a typical translation.

[6] The example is from the England & Wales Court of Appeal, 2002, WECA Crim 2912, and is taken from the AraucariaDB online corpus.

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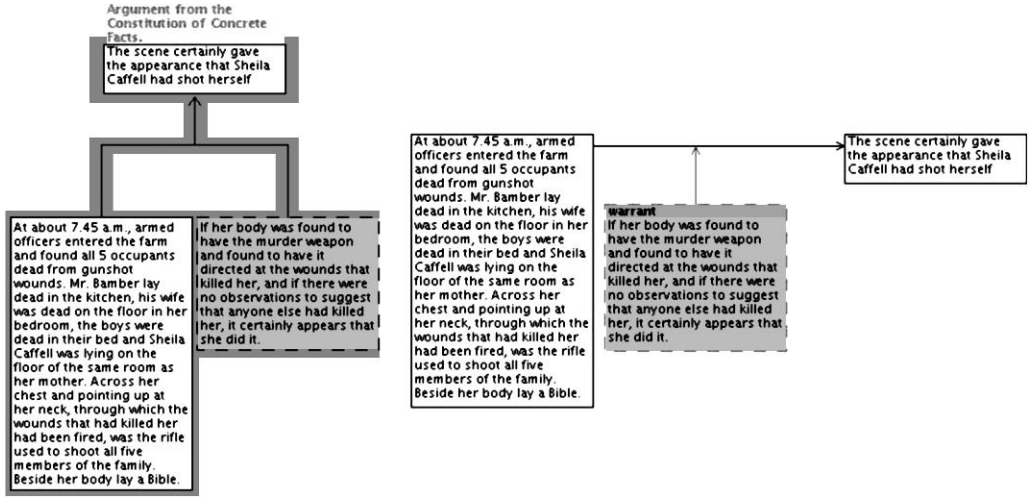
Argument from the Constitution of Concrete Facts.
The scene certainly gave the appearance that Sheila Caffell had shot herself
At about 7.45 a.m., armed officers entered the farm and found all 5 occupants dead from gunshot wounds. Mr. Bamber lay dead in the kitchen, his wife was dead on the floor in her bedroom, the boys were dead in their bed and Sheila Caffell was lying on the floor of the same room as her mother. Across her chest and pointing up at her neck, through which the wounds that had killed her had been fired, was the rifle used to shoot all five members of the family. Beside her body lay a Bible.
If her body was found to have the murder weapon and found to have it directed at the wounds that killed her, and if there were no observations to suggest that anyone else had killed her, it certainly appears that she did it.
At about 7.45 a.m., armed officers entered the farm and found all 5 occupants dead from gunshot wounds. Mr. Bamber lay dead in the kitchen, his wife was dead on the floor in her bedroom, the boys were dead in their bed and Sheila Caffell was lying on the floor of the same room as her mother. Across her chest and pointing up at her neck, through which the wounds that had killed her had been fired, was the rifle used to shoot all five members of the family. Beside her body lay a Bible.
warrant
If her body was found to have the murder weapon and found to have it directed at the wounds that killed her, and if there were no observations to suggest that anyone else had killed her, it certainly appears that she did it.
The scene certainly gave the appearance that Sheila Caffell had shot herself

FIG. 9. A linked argument as a single DWC complex.

It is important not to read too much into Fig. 9. We are not claiming that the diagram captures the full meaning of the particular argument structure; rather we are proposing a reasonable interpretation of one diagramming system in terms of the other, using those features of each system that are available. Some authors certainly do not regard a warrant as equivalent to a standard premise (Hitchcock, 2002) but since the standard system has no exact equivalent to the Toulmin warrant, the premise seems the best we can do. Figure 9 merely attempts to depict the argument so that it would make sense to workers using either system.

Figure 9 also highlights a closely related point of correspondence in the translation. In the standard analysis, the example has been marked as an instance of a particular argumentation scheme. Toulmin analyses do not usually employ such devices. However, as both Walton (1996) and Katzav and Reed (2004) have pointed out, argumentation schemes can be seen as analytic devices for handling warrants. So perhaps, Toulmin warrants are best translated as instances of particular schemes. There is unfortunately a practical problem with this solution. Where Toulmin analyses identify a warrant explicitly and can therefore mark any number of different warrants as such, models of argumentation schemes are in their infancy and are consequently limited. Though efforts at taxonomic work have begun (*vide* Walton and Katzav and Reed, ibid.), coherent and wide-ranging systems of argumentation schemes are simply not available. There is, however, a way forward. With recent proposals for seeing argumentation schemes as (at least in part) shorthand for a number of characteristic implicit premises or sets of implicit premises (Bex *et al.*, 2003), the explicit warrant of a Toulmin analysis might be seen as one of the linked premises associated with a scheme in a standard analysis. This leaves scope for the analyst to identify a scheme from those that are available, but does not necessitate such identification in the automated translation process. We return to the issue again in the context of rebutting, below.

One challenge remains. In the standard treatment, a linked argument can have any number of premises, while a Toulmin DWC complex typically contains only one datum and one warrant. Assuming we wish to preserve all the premises in the standard diagram when translating to

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Toulmin, we need to broaden the Toulmin diagram to allow either several data or several warrants or both.

Allowing several data in a single DWC complex is not necessary and seems to violate the spirit of the Toulmin model. The datum provides the basis from which to build an argument to support a claim. (It is possible that several different data can give rise to separate arguments, each of which supports the same claim. We consider this below.)

We are left with allowing a single datum with several warrants supporting a single claim. Though taking liberties with the Toulmin picture, this meets objectives (iii) and (iv) from the introduction, and most importantly, means that as described in objective (v), analysts working in either tradition need not worry about the foibles of the other (just because Toulmin diagrams can be constructed in which more than one warrant supports the move from datum to claim does not mean that such analyses will be at all common for those working in the Toulmin framework).

5.2.3 *Complex arguments.* A similar approach is required with another general problem. The standard treatment allows the construction of analyses of arbitrary complexity and depth. Toulmin was unconcerned with such larger scale structures and focussed therefore upon the simple, individual argument with its six components. The simplest solution is to allow each component in a basic Toulmin diagram to act as a claim and thus acquire its own support. This mirrors the structure of a standard diagram where each premise can in turn serve as a conclusion for other premises in layers below it in the tree.

In the Araucaria implementation of Toulmin diagrams, all elements in a Toulmin diagram except the qualifier are therefore allowed to act as claims and have support attached to them. In addition, we also allow more than one such construct to support a single claim.

5.2.4 *Qualifiers.* In the standard treatment, qualifiers (called ‘evaluations’ in the standard treatment tools in Araucaria) are rarely included in analyses and diagrams: when they are identified with support relations. Thus, qualifiers work as a modality or modifier, expressing the degree of support captured by an arrow between two argument components. This role is very similar to that carried out by the qualifiers in the Toulmin approach, so we translate one in terms of the other, as in Fig. 10. Here, we use Toulmin’s introductory example.

If there are multiple evaluations in a standard analysis, it is the one attached to the warrant (i.e. the premise that stands in the Toulmin ‘warrant’ role) that is identified as the qualifier. Most of Toulmin’s examples suggest that the qualifier modifies the scope of the warrant or is picking out the defeasibility, plausibility or presumptive nature of the warrant (so, in the example above, it is the ‘generally’ of the warrant that seems to require qualification of the claim with ‘presumably’). Toulmin (1958, p. 100) points this out explicitly in introducing qualifiers: ‘Warrants are of different kinds, and may confer different degrees of force on the conclusions they justify’.

5.2.5 *Backings.* A backing is a node that provides support for a warrant. In Toulmin’s original diagram structure, in which only a single DWC complex is considered, this is the only way in which a warrant could be supported. In Araucaria, as mentioned above, we allow any component of a Toulmin diagram, except for the qualifier, to serve as a claim in its own DWC construct. Thus, a warrant can be supported both by data and by backings.

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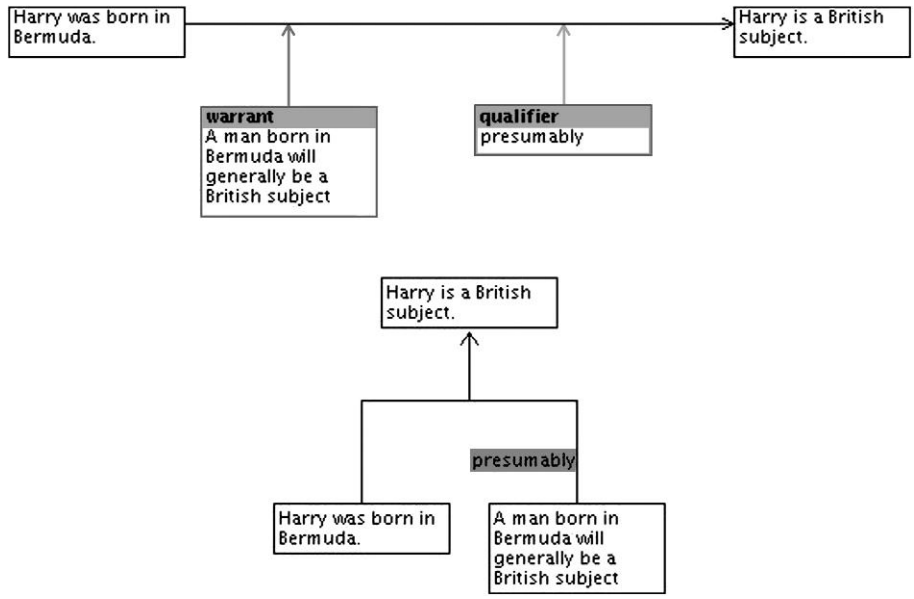
Harry was born in Bermuda.
Harry is a British subject.
warrant
A man born in Bermuda will generally be a British subject
qualifier
presumably
Harry is a British subject.
presumably
Harry was born in Bermuda.
A man born in Bermuda will generally be a British subject

FIG. 10. Mapping evaluations and qualifiers between Toulmin (upper) and standard treatment (lower).

The distinction between the two is subtle and is discussed more fully in Reed and Rowe (2005). Suffice it to say here that Araucaria allows a warrant to be supported by any number of data, in the same way as a normal claim, and also by any number of backings. A backing can, in turn, serve as a claim in its own DWC structure. In a standard diagram, a Toulmin backing is translated into a normal premise supporting the statement corresponding to the warrant.

5.2.6 *Rebuttals.* The final component of the Toulmin picture is perhaps the single-most troublesome and most interesting from a theoretical point of view: rebuttals. Most standard treatment systems involve some mechanisms for identifying conflicts: propositional negations, counterpositions, incompatibilities, etc. For some reason, there does not seem to have emerged a consensus on how best to deal with the issue diagrammatically. This has transferred directly into software implementations of diagramming methods: Reason!Able, e.g. uses coloured arrows (van Gelder, 2001), Argue! has lines terminated in diamonds (Verheij, 2003) and so on. Araucaria's solution is to use double-headed horizontal lines and restrict any given proposition to a single conflicting proposition (though that proposition in turn may have an additional conflicting proposition that is not the firstand so on). Whatever the exact mechanism for handling and representing these conflicts, the challenge is the same: is it possible to construe Toulmin rebuttals in terms of standard treatment refutations?

There seems to be (at least) four possible standard treatment interpretations of the Toulminian notion of rebuttal, summarized in Fig. 11.

The first candidate is that a rebuttal refutes its claim (we use rebuttal to refer specifically to that Toulmin role and refutes to refer specifically to the countering relationship expressed by a horizontal line in Araucaria's implementation of the standard treatment). The single largest problem with this approach is that it seems to fail to capture accurately the function of the Toulmin

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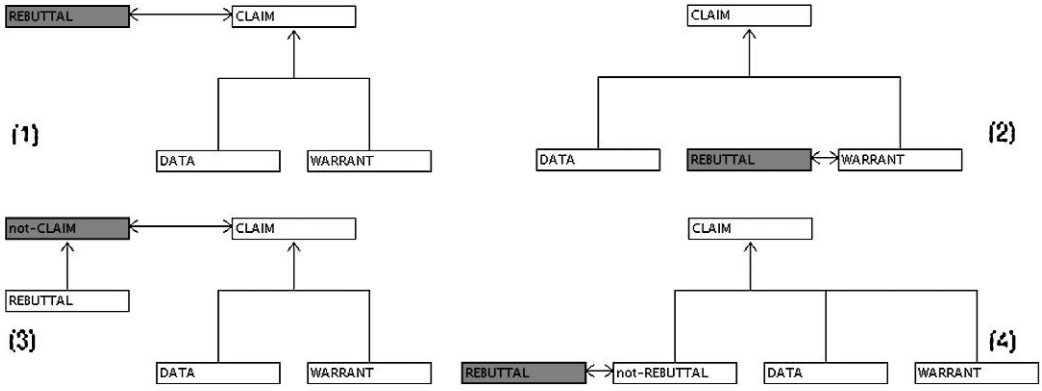

FIG. 11. Four candidate standard treatment interpretations of Toulmin rebuttals.

rebuttal. Not only the examples in Toulmin (1958) but even the very diagrams that label rebuttals with 'unless' suggest that rebuttals function not to refute the claim but to capture exceptions, objections or ways in which the argument may not apply (and may perhaps not apply in the case at hand). In this way, rebuttals are functioning in a manner akin to undercutters in Pollock's (1995) terminology. Undercutters take on the role of defeating an argument by attacking the inference, the way by which a conclusion was derived. Of course, in the Toulmin framework, the way by which a conclusion was derived is captured specifically by the warrant. Perhaps then, a second possible interpretation is more favourable: the rebuttal refutes the warrant. Again, though, this perverts the explication laid out by Toulmin. In the initial example, used in Fig. 10 above, the warrant is 'A man born in Bermuda will generally be a British subjects'. It is surely not the case that the rebuttal 'Both his [Harry's] parents were aliens' refutes this general statement. Even if the rebuttal is true in a specific circumstance, the general presumptive rule might nevertheless hold true. It might be argued that what the rebuttal does serve to do in this case is to lend implicit support to the conclusion that (in this case) Harry is not a British subject. This, then, offers a third possibility: that a rebuttal supports a refutation of the claim. The claim, C, has some counterposition which might be expressed loosely with the gloss, 'it is not the case that C'. This component itself is then supported directly by the rebuttal. Though this seems to work in the Harry case, it captures our intuitions poorly since the rebuttal is now interpreted as being entirely distinct from the data and warrant—under this interpretation, a rebuttal is interacting only with the claim and not with the way in which the claim is being derived. Furthermore, if the relationship between rebuttal and Pollock-style undercutter is close, then Pollock's analysis is in direct conflict with this third option, for, crucially, undercutters do not offer support for any counter to the conclusion. Pollock offers the example shown in Fig. 12.

Here, the fact that an object is illuminated by red light offers no support whatsoever for concluding that the object is not red. But it certainly casts doubt on the inference from its looking red to its actually being red.

Is there, therefore, a way of capturing this undercutting style of attack that seems so close to the Toulminian notion that a rebuttal serves to identify objections or exceptions to the way in which the conclusion has been reached using the warrant? There are two ways of achieving such a representation that are structurally identical, but semantically quite different. The first is to reify the inference. In this way, the DWC complex implicitly includes another component—represented, perhaps, by the

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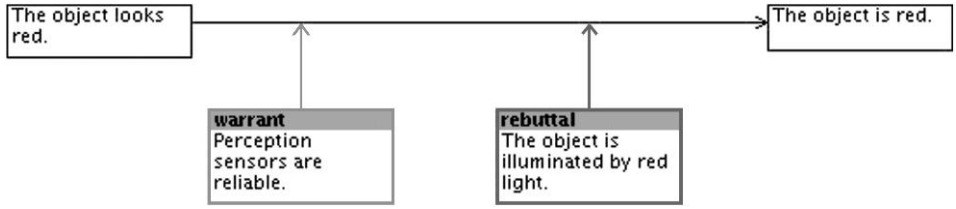

FIG. 12. Pollock-style undercutters as Toulmin rebutters.

horizontal line. The argument's inference is then, roughly, that given the datum and the warrant, it is reasonable to conclude the claim. It is this implicit premise that the rebuttal refutes. The approach has a direct counterpart in more traditional models of inference. A conventional approach to first-order logic uses the principle of modus ponens to get from premises A and $(A \rightarrow B)$ to conclusion B. But it is just as reasonable to extract the leap of faith or inference rule and identify it explicitly, as a premise: $A, (A \rightarrow B), (A \wedge (A \rightarrow B)) \rightarrow B$. The Carrollian regress looms instantly, and threatens the Toulmin model in an identical way if we go down this path. In addition to being a sly way of deductivising any non-deductive theoretical framework, a further problem is that it is far from clear that having the rebuttal refute this implicit premise is any better than having it refute the warrant. It may well be that the datum and warrant do still plausibly support the claim, even if the rebuttal holds.

The final alternative then is to introduce an implicit premise, but have that premise represent nothing more than the counter of the rebuttal. This implicit premise might be seen (by the analyst) as an additional warrant. It could be that it is an attack on the entire inference scheme. It could be a specialization of the warrant that is expressed. But perhaps, the most common and accessible interpretation will be that this missing premise is some kind of implicit assumption. In this way, it is very similar to the implicit components expressed in argumentation schemes (Walton, 1996; Katzav and Reed, 2004). The approach taken in Araucaria (partly because it is designed also to handle such theoretical structures) is to use this scheme-like approach in implementation (cf. Bex *et al.*, 2003). This approach naturally handles conditions of exception or rebuttal (Toulmin, 1958, p. 101) and circumstances in which the general authority of the warrant [should] be put aside (ibid.) as well as the full range of interpretations of rebutting used by analysts based on Toulmin's brief and ambiguous presentation. It also means that there is a clear relationship between components of argumentation schemes in the standard treatment and their (automatic) characterization in Toulmin diagrams.

There remains a problem. The function of a rebuttal in a Toulmin diagram is, on our understanding of it, one of challenging an inference. The function of standard treatment refutation, at least as implemented in Araucaria, is one of representing some sort of dissonance between statements. These two theoretical frameworks thus manifest a fundamental difference in the way they handle inference: essentially, the former has a metaphysical basis that identifies multiple forms of inference, while the latter is cast in the deductivist mould. The only straightforward way in which translation between them might be accomplished is to reify the inference types of the former so that they can be represented explicitly as statements in the latter. The problem then is that it might be argued that the richer model is weakened by its translation to the more formal model. The first observation to make in response to such a challenge is that it is interesting and perhaps surprising that an apparently simple diagramming translation problem is intimately tied to the great deductivist debate that is still going strong (witness, e.g. Groarke, 1999, and its responses). We do not here seek any kind

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of resolution of that debate, but rather seek to build a pluralistic approach that allows analysts and researchers to work within their many theoretical frameworks, allows work conducted in one to be reused in another and, perhaps, allows research exploring the differences between frameworks to have practical support.

5.3 *Translating Wigmore analyses*

5.3.1 *Introduction.* The diagram structure introduced by Wigmore (1913) is used primarily for the analysis of evidential arguments. Wigmore defines four broad categories of premises: testimonial and circumstantial evidence, such as would be presented by witnesses or introduced by the judge as factual evidence; explanatory evidence, which is designed to argue against testimonial or circumstantial evidence and corroborative evidence, which supports previously introduced testimonial or circumstantial evidence.

5.3.2 *Evidential relations.* A testimonial or circumstantial evidence node may have up to three supporting groups of nodes: other testimonial or circumstantial evidence, explanatory evidence and corroborative evidence. Each of these three groups of nodes are represented in the diagram by a set of nodes that have support edges converging on a single edge which then supports the parent node.

There is a superficial diagrammatic resemblance between the Wigmore notation for a group of supporting nodes and the linked argument structure in the standard diagram. It is tempting, therefore, to infer an equivalence between these two structures. However, we believe this correspondence is illusory. The linked argument in a standard diagram implies that all the premises making up the linked group of nodes are required for the connection between these nodes and the node they support. Common examples of linked arguments are found in argumentation schemes: the argument from expert opinion, e.g. requires both that the experts have appropriate domain knowledge and that the proposition they are advocating lies within that domain. In a Wigmore diagram, however, all nodes of a given type that support another node are grouped together, regardless of whether some of these nodes form linked arguments and others stand alone as support for the parent node.

A Wigmore diagram also strongly reinforces pictographically the tripartite grouping of all evidence. One possible way of representing a Wigmore analysis is therefore to introduce virtual ‘aggregation’ nodes in the argument that aggregates all the corroborative evidence supporting a node, all the explanatory evidence supporting a node and all the other (i.e. testimonial or circumstantial) evidence supporting a node. These intermediate nodes might then be further supported in their turn by convergent arguments from the various premises. An analysis such as Fig. 13(a), e.g. might be rendered at a deep level by the representation in Fig. 13(b), with C1, Ev1 and Ex1 aggregating the corroborative, testimonial and explanatory evidence for claim 1, respectively.

In this way, the ontological status of nodes in the Wigmore analysis (i.e. whether they are corroborative, explanatory or testimonial/circumstantial) is captured by structural features in the AML deep representation. Unfortunately, this misrepresents the arguments in an important way. The role of ‘corroborating’ evidence is, as the terminology suggests, one of working with elements of testimonial and circumstantial evidence to support a claim. In this respect, it is most similar to traditional linked argumentation—but the linkage crosses the groupings in Fig. 13(b)—so, e.g. it might be that 2 and 4 form a linked argument and 3 and 5 form a linked argument. The analysis in Fig. 13(b) not only makes such relationships opaque but also absolutely proscribes the representation of such relationships.

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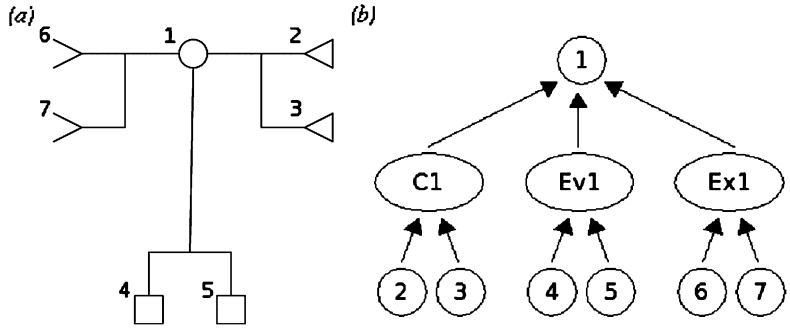

FIG. 13. A sample Wigmore diagram (a) and possible deep structure representation (b).

The problem is compounded in that an analysis performed in the Wigmore style provides no mechanism for determining which premises of a claim are linked and which are not. Thus, we have no choice but to represent all the nodes supporting another node in a Wigmore diagram as single, unlinked nodes in a standard diagram. Similarly, there is no distinction in a standard diagram between the concepts of explanatory, corroborative, testimonial or circumstantial evidence, so all nodes from all these groups must be treated equally when drawn in a standard diagram.

We can use similar considerations to translate in the reverse direction: from standard to Wigmore. A standard diagram does not contain any information on the type of evidence represented by a node, so we really have no choice but to represent all standard nodes, linked or convergent, as one node type in Wigmore. For convenience, Araucaria interprets all standard nodes as testimonial affirmatory nodes (represented by a plain square) in Wigmore.

The reader may be wondering how these rules conform to our desire to use the AML structure to represent all arguments as standard and then translate to other diagram types. If Wigmore diagrams contain properties not representable in standard, how do we store these properties in AML, thereby ensuring that our second *desideratum* is met? The answer is that no interchange format will be able, *a priori*, to cater for all possible representational and operational schemes that involve argument (Chesñevar *et al.*, 2006). Instead, AML is designed to support extensibility through a simple 'role' mechanism that allows new ontological categories to be catered for in the representation, without the representation having to revise existing analyses. Specifically, individual propositions within an analysis can be marked as taking on a particular role in a particular class. So, e.g. in the Toulmin class, a proposition might be marked as a 'warrant'—a concept that only makes sense in the context of Toulmin analyses. Of course, if these extensions are not only numerous but also individually significant, then the benefits of an interchange language such as AML are eroded. The exponentially expensive problem of translation between the different classes returns. AML takes a pragmatic solution, providing as much generic capability as possible, and supporting extensions that are intended to be small scale. If particular software systems aim to make use of these extensions in translation, then they are not prohibited from doing so.

In the Wigmore case, the four basic types each represent different roles: corroborative, explanatory, testimonial and circumstantial.

5.3.3 *Evidential ownership.* A further complication arises in that Wigmore diagrams distinguish explicitly between evidence offered by prosecution and that offered by defence (the extra top-most

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bar indicates diagrammatically the latter). Though neither Araucaria nor AML pretends to be able to handle either dialogue or a record of dialogue, they nevertheless both support identification of 'owners' in standard analyses—i.e. the identity of the individual, group or viewpoint of which a given proposition is claimed. This is useful for analysing arguments in which, e.g. a counter-argument to the author's position is presented and countered. The same machinery can be put to use for distinguishing between prosecution and defence arguments, inasmuch as Wigmore analyses allow the specification of just exactly those two owners and no others. This is an example of *desideratum* (iii) driving representational reuse.

5.3.4 *Evidential sense.* Wigmore explicitly distinguishes between evidence that is affirmatory and evidence that is negatory. Unfortunately, Wigmore's presentation leaves it unclear as to exactly what is meant by negatory evidence (and there are few examples of it in his writings). There are three possible interpretations:

1. Evidence can only be defined as negatory with respect to other evidence (implicit or explicit) that is affirmatory. So, e.g. the claim that 'the murderer was in the garden' might be classified as negatory with respect to another claim that 'the murderer was in the house'.
2. There is something intrinsic to negatory evidence which means that a human can inspect a claim and determine whether or not it is negatory. Such a determination could conceivably be related to burden of proof (so, e.g. a claim such as 'there is no evidence that the murderer was in the house' as affirmatory).
3. Negatory means virtually nothing at all, making only a rhetorical distinction rather than a truth functional one (so that, e.g. 'the murderer was not in the house' is negatory while 'the murderer was in the garden' is not).

Option 1 is at the heart of most concepts of negation and contrariness: in propositional accounts, *p* derives its interpretation from the meaning of *p*; in Araucaria-style analyses, a refutation links a claim and counterclaim; in the Toulmin diagram, a rebuttal works to cancel the data–claim connection. Yet, there is no indication that this was what Wigmore intended, and the few examples suggest that evidence can be negatory quite independently of other claims that are available. Option 2 would require highly contentious linguistic and philosophical assumptions, but in any case, is computationally intractable and therefore of limited interest here. Option 3 though perhaps one of the most disappointing from a formal point of view seems to resonate most closely with Wigmore's account. There is social psychological evidence that positively presented evidence may be looked upon more favourably than negatively presented evidence (McGuire, 1968). Perhaps therefore, it is this linguistic or rhetorical effect that Wigmore is tackling with his 'negatory' class (given that juratorial presentation is a constant motivation for Wigmore). For a representation scheme, this requires nothing more than a single additional role tag for the evidence 'sense' indicating whether a piece of evidence is affirmatory or negatory. We return to the problem of 'negatoriness' in the context of the relations between propositions, below.

5.3.5 *Force of premise support.* The categories of support forces in a Wigmore diagram offer interesting scope for finding corresponding structures in a standard diagram. Looking back at Fig. 8, we see that there are various symbols such as arrowheads, double arrowheads, Xs, double Xs, little circles and so on that are drawn on the support edges. These symbols all indicate either the degree

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or force with which that edge implies support for the node to which it leads or whether the force is affirmatory (supports the conclusion) or negatory (detracts from the conclusion).

The degree of support has a natural correspondence in the evaluation feature of a standard diagram (which has been equated with the qualifier in a Toulmin diagram). We can therefore use the Wigmore description of the force as an evaluation label in a standard diagram. For example, the single arrowhead on the support edge from nodes 2, 3 and 4 to node 1 in Fig. 8 indicates 'provisional' support, while the double arrowhead on the edge leading out of node 3 indicates 'strong' support. Other symbols have similar meanings: a complete list can be found in Wigmore (1913). One oddity is the 'detracts' force, which could be equated with negatory support. Wigmore, however, does not do so, and therefore neither does Araucaria's interpretation of Wigmore analysis—even though that leaves diagrams in which 'support' arrows are, somewhat counter-intuitively, labelled with 'detracts'.

5.3.6 *Force of evidential group support.* An important complication is that Wigmore analyses permit a very slightly finer-grained analysis of these evaluative components. For each premise, an evaluation is possible—in Fig. 8, e.g. premises 2, 3 and 4 can each have independent evaluations. In addition, however, the set of testimonial evidence (composed of premises 2, 3 and 4) can also itself have an evaluation that is separate again. Recall from section 5.3.2 that the ontological categories into which evidence is divided are simply being marked as 'role' tags on the evidence nodes themselves in AML, with the result that there are no nodes in the deep representation corresponding to the set of testimonial evidence. There is, therefore, no edge in that deep representation to which an evaluation can be attached. Where then does such evaluation belong? The solution is to recognize that these evaluations are intimately tied to the claim to which they lead—i.e. the evaluation on a set of testimonial evidence is not attached to any particular member of the set, but rather to the claim that the set putatively supports. For each of the three sets that a given claim can have (corroborative, explanatory, testimonial/circumstantial), a new role tag is provided that takes the evaluative force marked for that edge. This role tag is attached to the claim.

5.3.7 *Negatory force.* The presence of a small circle on an edge in a Wigmore diagram (such as that on the edge leading from node 7) indicates negatory force, which means that the node argues against its parent. This clearly suggests some relation to the refutation in the standard model (or the rebuttal in Toulmin). When translating the Toulmin rebuttal into a standard analysis, the closest match is to introduce an 'added negation' so that in essence a rebuttal is the contrary of an implicit warrant. In the Wigmore case, it may seem that we have a more straightforward situation since Wigmore does not consider the subtle nuances of the Toulmin datum–warrant–rebuttal model. If a node supports another node with negatory force, then in Wigmore, the implication is that the first node counters or refutes the statement being made in the second node. Thus, it may seem that we could simply map any node with negatory force on another into a refutation in the standard model, as suggested in Fig. 14.

The problem here is that the standard model (with its heritage in a propositional account) only allows a maximum of one refutation for any given node (i.e. refutation is a relationship between a proposition and its contrary, between p and not-p). In Wigmore, however, any number of nodes may support another node with negatory force. More importantly, Wigmore's use of negatory force seems to be functioning in a different way, typically functioning not as straightforward refutation but rather much more like the rebuttal in a Toulmin diagram. The challenge can be addressed by

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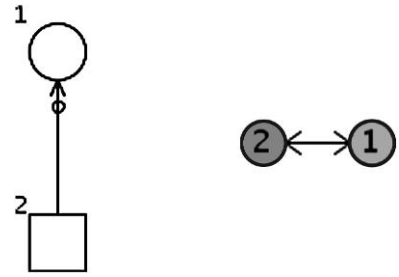

FIG. 14. Simplistic negatory-to-refutational translation from Wigmore (a) to standard (b).

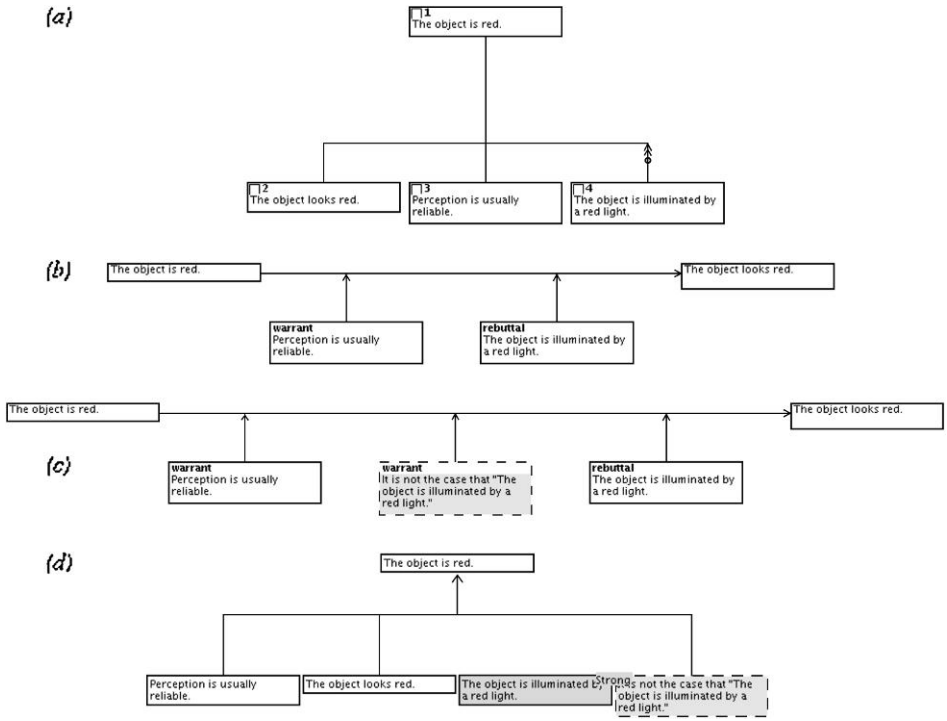

FIG. 15. (a) Pollock's example analysed as a Wigmore diagram; (b) its translation into a Toulmin diagram; (c) the Toulmin diagram showing its implicit 'added negation' and (d) the translation to a standard analysis (NB: Qualifiers have been omitted to improve clarity.).

exploiting this similarity with the Toulmin case: by introducing an added negation which is refuted directly by the node with negatory force. This added negation node in turn supports (positively) the node supported directly in the Wigmore diagram. In fact, the simplest way of understanding the translation is not by comparing it with the standard treatment at all but rather by considering its translation to a Toulmin diagram (which then, of course, yields a standard analysis by existing translation mechanisms). Figure 15 demonstrates the idea using an example from Pollock (1995).

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6. Conclusions and future directions

Araucaria is being rewritten over the summer of 2007 to take advantage of the feedback received from both academic and professional user communities and also to take advantage of recent advances in the field of computational modelling of argument. One fundamental change is the move to using the AIF (Chesñevar *et al.*, 2006), as the primary means of storage. In addition to increased flexibility, this will allow greater reuse of the arguments that Araucaria visualizes, as it will provide access to the rapidly growing community of AIF users. One example of the increased power offered by the AIF is that, from a computational point of view, arguments can be conceived of as graphs, rather than as trees. In practice, this means that supporting divergent argumentation (in which a single premise supports multiple conclusions) becomes a simple matter. Another important issue is to address a central problem in translating Toulmin diagrams: how to account for warrants. In his unpublished commentary on an early version of Reed and Rowe (2005), J. B. Freeman expresses grave concern over the association of warrant with implicit conditional. A promising alternative, at least in some cases, is to emphasize the correspondence between warrants and argumentation schemes. This is the avenue currently under investigation. Finally, there are many other popular diagramming mechanisms, and at least some of these pose further research questions. The next version of Araucaria will explore ways of visualizing Pollock (1995) inference graphs and Dung (1995) argumentation frameworks among others. Finally, where earlier versions of Araucaria focussed solely on the structure of argument, it has become clear that offering control over the appearance of a diagram (e.g. in respect of its layout) is of crucial importance in some scenarios. Such control will therefore become a central feature in the new version.

Despite a rather long list of planned revisions, the Araucaria work to date has demonstrated that a pluralist approach is intellectually intriguing and technically viable. The increasing user base of the software further demonstrates that it is a popular approach to take. By providing implemented methods for interchange and translation, our goal is to support the development and reuse of argument resources, analyses and techniques within and between different communities of usage in argumentation theory, communication research, law, computer science and the many other disciplines in which argumentation and its visualization have a role to play.

Acknowledgements

This paper aims to provide an overview of how Araucaria tackles the concept of pluralism and how that ideal fits into the landscape of software support for argumentation. As a result, some of the issues tackled here have been presented in more depth elsewhere. Specifically, Section 4.2 and parts of 5.2 (on Toulmin argumentation) have been condensed from Reed and Rowe (2005) and similarly Section 4.3 and parts of 5.3 (on Wigmore argumentation) have been condensed from Rowe and Reed (2006). CR would like to thank Prof. Peter Tillers for his kind invitation to the symposium at which an earlier draft of this work was presented and for the financial support provided by him through the Cardozo Law School at Yeshiva University in New York. The detailed response provided by Prof. Dale Nance at that event was extremely helpful, and we are indebted to him for his comments. The anonymous reviewer's comments have also been valuable in improving the structure and presentation of the paper. Any errors that remain are, of course, entirely the responsibility of the authors.

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